2. — *Elements of Physical Manipulation.* By PROFESSOR E. C. PICKERING. New York: Hurd and Houghton. 1873.

THIS book is an evidence of the increased attention which is paid to the subjects mechanics, light, sound, heat, and electricity, now embraced under the head of physics. For many years the ground of physics was a tract of undefined boundaries, over which chemists and mathematicians roamed at will. Sir Humphry Davy, Faraday, Wollaston, and many other eminent chemists, made as brilliant discoveries in this neutral territory as in their own especial domain. To day the chemist finds his own field so large as to occupy all his mental power; and the student of physics discovers that the subjects of light, sound, heat, and electricity cover grounds so extensive that he cannot make incursions upon his neighbor's domain of chemistry. We therefore have in the universities and colleges of the present day distinct chairs of chemistry and physics. To the chair of chemistry there is attached a laboratory in which the student works practically; on the other hand, it has not been considered essential that the student of physics should do more than attend the lecture-room and see the manipulation of the professor. The reason that this difference of teaching the two sciences should have existed is very apparent. To demonstrate a law in physics, technically so called, more refined and complicated apparatus is needed than in what Theodore Winthrop terms "splitting atoms and unbraiding gases." With test-tubes and a few reagents, a student in chemistry can perform many experiments with small expense; whereas, in physics, the apparatus cannot be duplicated without large outlay; and the danger of its injury in the hands of inexperienced men is very great. The professor in chemistry can start the student upon a branch of analysis, in which, with the aid of a good text-book, — like Eliot and Storer's manual, for instance, — he does not require much individual assistance from the professor; large classes can pursue their studies in a laboratory at the same hour, the number being limited only by the laboratory accommodation. The instructor in physics, on the other hand, if he admits students to the use of his instruments, must give each man individual and constant attention, unless the student happens to have large skill and experience, which does not often happen. Therefore, distinguished professors of physics, in Germany and in England, have never had more than four or five young men in their laboratories at one time.

The value of laboratory work in the professional training of chemists, naturalists, doctors of medicine, and of men about to devote themselves to technical branches of manufacture, is well recognized. The importance of this work as a means of strengthening the judgment, and cultivating the powers of observation also, cannot be too much dwelt upon.

A student, with an undue balance of the imaginative powers and with a good knowledge obtained from books, enters the laboratory and takes his place at the table whereon is placed the apparatus with which he is to experiment. He has read about the subject all his school life, and was instructed in physics in a high school before his entrance to college. He is now told to use the apparatus which he has read about. Face to face with the thing itself, he stands aghast. He realizes, in a dim way, that practical life and the actual duties of a profession will confront him, as this battery or that spectroscope now does. He finds that his reading knowledge on the subject in hand is of no practical use, simply because it is not definite. In that moment he learns, perhaps for the first time, the value of definite ideas; and a feeling comes over him that his knowledge of subjects out of the domain of physics may fail when he comes to the point of applying it. He can be readily pardoned, however, for a want of technical skill in the use of this screw or that slide. He goes more confidently at work, and at last brings out a result which he characterizes as "about right." He is very much dejected when he is informed that no margin of error is allowable; and that results which are not exact are useless. He goes away much dispirited by his day's experience; his observations are useless; they have been taken at random, without method and without proper sequence. He therefore relapses with a sigh of relief into studies which allow his mind to wander freely without penitentiary bounds or limits. His next essay may be more successful; but weeks and months of patient work are required to overcome deficient training. Let us stand beside him after experience has had its more or less perfect work. He is told to perform a certain experiment; his questions are to the point; he sees what is necessary to accomplish his object; what errors are to be expected and how to provide against them; and his manner of handling the instruments shows that, having grasped the salient points of the idea presented, he has the power of working it out. He has got an insight into a new manner of using his mind, substantially different from that with which he has been familiarized in his linguistic studies. He realizes what Helmholtz vividly describes in an opening address at the

Naturforscher Versammlung in Innspruck, in 1869: "At one time we have to study the errors of our instruments, with a view to their diminution, or, where they cannot be removed, to compass their detrimental influence; while, at other times, we have to watch for the moment when an organism presents itself under circumstances most favorable for research. Again, in the course of our investigation, we learn, for the first time, of possible errors which vitiate the result, or, perhaps, merely raise a suspicion that it may be vitiated, and we find ourselves compelled to begin the work anew, till every shadow of doubt is removed. And it is only when the observer takes such a grip of the subject, so fixes all his thoughts and all his interest upon it, that he cannot separate himself from it for weeks, for months, even for years, cannot force himself away from it, in short, till he has mastered every detail, and feels assured of all those results which must come in time, that a perfect and valuable piece of work is done. You are all aware that in every good research the preparation, the secondary operation, the control of possible errors, and especially the separation of the results attainable in the time from those that cannot be compassed, consume far more time than is really required to make actual observations or experiments." The influence of such work upon the powers of the mind is necessarily very strong, even if the student does not advance to the point of making original investigations. The problem then presents itself of extending a valuable method of study now pursued by a few in physics to the many, and of breaking up the pernicious system of recitations from illogical and badly arranged text-books in natural philosophy. The professors of physics in our American colleges, although recognizing the value of laboratory work, have been loath to give so much time and energy as a system of laboratory work in physics would necessarily require. It has been reserved for Professor Pickering to show how the difficulty of time and attention, the expense in duplication of apparatus, can be surmounted. No one who has not had charge of a physical laboratory can form any idea of the amount of originality and ingenuity required to devise simple experiments suitable for untrained students in physics. In this work, Professor Pickering has arranged experiments in mechanics, light, and sound, with valuable hints upon methods of work. Especial stress is laid upon quantitative work; and the methods of probable error, interpolation, and various criteria for forming judgment of the weight of results, are explained at length. Many of the experiments here described are entirely original. It has evidently been the aim of the author to adapt the book to the possible requirements of the high school of the future;

the apparatus, therefore, recommended, is for the most part simple and cheap.

The book is a very suggestive one; and teachers of physics in high schools and colleges cannot fail to profit by it.

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3. — *Autobiography.* By JOHN STUART MILL. New York: Henry Holt and Company. 1873.

THE impression that is left on the reader's mind by this remarkable book is by no means a simple one. What one wishes to find is an explanation of the growth of Mr. Mill's opinions and an account of that inner life which interests us sometimes in fools as much as in philosophers. But this second part is almost wholly swallowed up by the first. From the cradle Mr. Mill was instructed; his whole life was one of intellectual training; so that while his brain was made an admirable instrument, while he wins our warmest admiration as a worker, we cannot help feeling a certain distrust of the accuracy of his opinions when we see the one-sidedness of his education, and our affection for him personally is made greater by the view we get of his sincerity, unflagging toil, and the lack of sympathy with anything but his intellectual nature which marked so much of his life.

How thorough was his training can be judged by the fact that he had no remembrance of the time when he began to learn Greek; that before he was seven years old he read Robertson, Hume, and Gibbon, making notes upon them all while reading; that he had almost no playthings and very few children's books; and that at the age of twelve, after having read more Latin and Greek than most college graduates, and writing a history of the Roman government, he compiled from Livy and Dionysius, which would have made an octavo volume, read several Latin treatises on the scholastic logic, and Hobbes's *Computatio sive Logica;* that in 1819, when he was but thirteen, his father took him through a complete course of political economy. At eighteen this overworked boy, who had been without companions of his own age while making these vast preparations, began to write for the "Westminster Review," having a year or so before been a contributor of various historical articles to the daily papers. So much work, it seems, could be forced out of his brains; but this artificial system of education was succeeded by a period of melancholy reaction. He says: —

"I was in a dull state of nerves, such as everybody is occasionally liable to; unsusceptible to enjoyment or pleasurable excitement; one of those